Q. What is your name, job title and address?

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Q. What is your formal education?

A. Bachelor of Science Degree from The University of Washington College of Fisheries in 1968.

Master of Science Degree from the University of Washington College of Fisheries in 1972.

Q. What have you published?

A. <u>The short-term physical and biological effects of stream channelization at Big Beef Creek, Kitsap County Washington.</u> 1972. M. S. Thesis, University of Washington, College of Fisheries.

<u>The effects of logging road landslide siltation on the salmon and trout spawning gravels of Stequaleho Creek and the Clearwater River basin, Jefferson County, Washington, 1972-78.</u>

<u>1979.</u> Fisheries Research Institute, University of Washington. FRI-UW-7915.

<u>Application of sediment budget studies to the evaluation of logging road impacts.</u> Reid, M. L., T. Dunne. and C. J. Cederholm. 1981. New Zealand Journal Hydrology. 20:49-62.

<u>Impact of forest management on coho salmon (Oncorhynchus kisutch) populations of the Clearwater River, Washington: A project summary.</u> 1987. Symposium: Streamside Management - Forestry and Fishery Interactions. College of Forest Resources, University of Washington, Contribution No. 57.

<u>Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-81. 1982.</u> Symposium: Salmon and Trout Migratory Behavior. University of Washington, College of Fisheries.

<u>Low-cost enhancement technique for winter habitat of juvenile coho salmon.</u> 1988. N. Amer. J. Fish. Manag. 8:438-441.

<u>Fate of coho salmon (Oncorhynchus kisutch) carcasses in spawning streams.</u> 1989. Can. J. Fish. Aquat. Sci. 46:1347-1355.

<u>Response of juvenile coho salmon and steelhead to the placement of large woody debris in a coastal Washington stream.</u> 1997. N. Amer. J. Fish. Manag. 17:947-963.

Q. What are your present job responsibilities?

A. As senior salmon biologist for the Department of Natural Resources (DNR) for the past 17 years, I have been involved in most research, planning, and implementation issues pertaining to salmon for this department. Over the years I have contributed in large degree to the DNR's resource management plans, including: The Forest Land Management Plan, The Forest Resource Plan, the Habitat Conservation Plan, and The Riparian Silviculture Guidelines. I have been involved in these management plans at both the development and implementation stages. In many cases my own research has laid the foundation of these plans, and acting on a field consultant basis I have been involved in assisting field foresters with implementation. I also perform other salmon related work (i.e., Cross Cascade Pipeline) for the DNR as assigned.

Q. What is the subject matter of your testimony?

A. Below, I have answered several questions pertaining to the route of the Cross Cascade Pipeline, and the potential for impacts on salmon and their habitats.

Q. For each river, tributary, wetland or other water body adjacent to or crossed by the pipeline, what are the fish population(s) associated with that water body?

A. Refer to the Cross Cascade Pipeline Draft Environmental Impact Statement (DEIS). See the DEIS 3.7.1.3 Fish Habitats and Utilization, for the details on the various tributaries of the below mentioned major river basins. The major river basins involved are the Sammamish River Basin, Snohomish River Basin, Snoqualmie River Basin, South Fork Snoqualmie River Subbasin, Yakima River Basin, Upper Yakima River, Middle Yakima River, and Columbia River Basin.

Q. For each fish population identified, state whether or not that population has been listed by *the federal government under the (Federal) Endangered Species Act. In addition, which populations are currently considered candidates for listing?*

A. Many salmonids (salmon, trout and char) are either listed as endangered or are candidates for listing, under the Federal Endangered Species Act (ESA) (1973). Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. According to the United States Fish and Wildlife Service, Department of Interior, (50 CFR Chapter 1 (10-1-97 Edition) - *Harass* in the definition of "take" in the Act means an intentional or negligent act or omission which creates the likelihood of of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. *Harm* in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

The following information is from the Cross Cascade Pipeline DEIS. DEIS 3.7.1 FISHERIES - Affected Environment. It is accurate to the best of my knowledge.

On March 9, 1998 the National Marine Fisheries Service published a proposed rule to list the Puget Sound chinook salmon evolutionary significant unit (ESU) as threatened, and to propose designation of critical habitat for this ESU. The Puget Sound chinook salmon ESU consists of all naturally spawned spring, summer, and fall runs of chinook salmon in the Puget Sound region. Within the project area, the Snohomish River mainstream, the Tolt River, and Cherry and Harris Creeks support Puget Sound chinook salmon.

On June 10, 1998, the USFWS listed the Columbia River population segment of bull trout as threatened and proposed to list the Coastal Puget Sound population segment of bull trout as threatened. Within the project area, Keechelus Lake and many of its tributaries, and the Yakima River and many of its tributaries, support this bull trout population segment. The Coastal Puget Sound population segment of bull trout encompasses all Pacific Coast drainages between the Columbia River and the Canadian border. Within the project area, bull trout occur in the Snohomish River and Snoqualmie River Basins.

The middle Columbia River steelhead Evolutionarily Significant Unit (ESU) was proposed for listing as threatened on March 10, 1998. The middle Columbia River steelhead ESU occupies the Columbia River Basin and tributaries above (but excluding) the Wind and Hood Rivers upstream to and including the Yakima River. Within the project area, the Yakima River mainstream and Cabin, Big, Little, and Swauk Creeks support middle Columbia River Steelhead.

The upper Columbia River steelhead ESU was listed as endangered on August 18, 1997. The upper Columbia River steelhead ESU occupies the upper Columbia River Basin from (but excluding) the Yakima River upstream to the U.S.-Canadian border. Within the project area, the Columbia River mainstream and Getty's Cove support Columbia River steelhead.

The upper Columbia River spring-run chinook salmon ESU was proposed as endangered on March 9, 1998. Although this ESU occupies areas upstream of the project area (above Rock Island Dam), upper Columbia spring-run chinook salmon would use the mainstream Columbia River in the project area as a migration corridor. The mainstream of the Columbia River, including reaches in the project area, has been proposed for designation as critical habitat for this ESU.

Several additional fish species could be listed or proposed for listing within the operational time frame of the proposal. These include coho salmon, sea-run cutthroat trout, and westslope cutthroat trout.

Q. What are the general life history stages of the wild salmonid fishes found in these rivers?

A. Salmon evolved in freshwater habitats that are typically characterized by accessible cool, clean water with abundant woody debris or other forms of cover, clean spawning gravels, food, and a balanced population of predators. Because the inland freshwater environment of this state is far less productive than the ocean environment, salmon evolved an anadromous life cycle that allowed them to take advantage of both the freshwater and marine environments. Some nonanadromous cutthroat, rainbow, and bull trout, however, spend their entire life in freshwater.

A typical anadromous salmonid life cycle has five main stages: (1) spawning and egg incubation, (2) freshwater rearing, (3) estuarine migration and rearing, (4) ocean rearing, and (5) return migration and spawning. The nonanadromous life cycle is characterized typically by stages (1) (2), and (5). The amount of time spent in each life stage varies greatly by species and within species. This sequence of life cycle events is characterized by high abundance of small individuals in the immature stages of life, with relatively few large individuals surviving to adulthood. Survival rates from egg to adult of 0.1%, over a single generation, are not uncommon.

The chum, pink, sockeye, chinook, and coho salmon all die after spawning is complete (semelparity). This life history strategy has evolved because of the need to have a greater portion of the energy obtained from ocean feeding devoted to gamete production and juvenile survival. Consequently, survival after spawning no longer offered an advantage to these species.

The iteroparous (repeat spawning) life history strategy of the rainbow, cutthroat, and bull trouts probably occurred in the headwater reaches of larger rivers, where resident populations could be maintained year around. These fish generally were smaller in size, less fecund, and had sparser distribution and abundance than anadromous forms. However, by retaining iteroparity, calamitous losses of young due to floods or drought could be compensated for in subsequent breeding seasons.

Chinook, coho, chum, sockeye, and pink salmon, and bull trout spawn between the months of August and February, at a time when stream flows are increasing and water temperatures are declining. While steelhead and cutthroat generally spawn between December and June, when stream flows are decreasing and water temperatures are increasing. For successful development of eggs to occur the gravel should be stable, relatively clean of fine sediments, and well oxygenated. It has been found that during nest (redd) excavation, salmon are able to clean gravels by purging them of fine sand and silt particles; however, if there is a continual source of sediment in the stream, the redd can become silted in again. When the redd is complete the eggs are burried from 5 to 40 centimeters below the gravel surface, depending on species and female size.

After a few months of incubation, salmonid fry swim up through the gravel and emerge into the stream. The emergence season will depend on species and race of fish, for example chum and chinook emerge in late winter-early spring, while steelhead and cutthroat emerge in early to mid summer. Survival from egg deposition to emergence can be quite variable, ranging from 0 to 77% in coho salmon. Upon emergence the fry begin feeding on a variety of aquatic and terrestrial insects, and become prey for a wide variety of fish, birds and mammals. After emergence fry vary in length, averaging between 25 to 40 mm, and can be seen actively feeding in streams.

Juvenile salmonids that rear for extended periods of time in freshwater (i.e., months to years) include coho, chinook, and sockeye salmon; and rainbow, cutthroat, and bull trout. After the first summer of rearing in freshwater, juvenile coho salmon average 50 to 90 mm in length, and may weigh 2 to 5 grams each. Juvenile rainbow and cutthroat trout tend to be smaller at the end of their first summer of freshwater rearing, more in the range of 40 to 70 mm in length. A crucial time in the life of juvenile salmonids, particularly coho, steelhead, and cutthroat, that rear for extended periods of time in freshwater occurs in the late summer months when flows reach their annual lows. During this period the volume of aquatic habitat shrinks to a minimum, which may lead to increased competition between and within species. These conditions cause fish to emigrate to downstream freshwater habitats, and also to estuaries.

At the watershed or reach scale, the salmonid community is a highly complex association of interacting populations sharing a similar set of environmental conditions. The interrelationships that occur between species have evolved, in part, through dynamic adaptations for partitioning limited freshwater resources. In general, as you travel downstream from the small headwater reaches the number of species increases with larger channels. Frequently, the upstream-most occurring salmonids are the bull trout and coastal cutthroat trout; while chinook, chum, and pink salmon tend to occur in the lower reaches of river systems. Steelhead and coho tend to distribute throughout the middle to lower reaches of the river systems, in many cases overlapping the downstream species. All species can be found rearing in lake systems to a greater or lesser degree, however, the sockeye salmon requires a lake in its lifehistory. The sockeye rear for 1 to 3 years in lakes as juveniles. The particular location of any given species, however, is highly influenced by a complex combination of abiotic (i.e., velocity, microhabitat structure, pool:riffle, temperature, channel gradient, etc.) and biotic factors (i.e., fish density, competition, predation, etc.).

Where species overlap, a number of temporal and behavioral differences between species facilitate coexistence. For example, in many streams, coho, steelhead and cutthroat spend 1-3 years rearing together in freshwater, and have evolved means of partitioning the available resources. Though their distributions frequently overlap within a basin these three salmonid species have markedly different microhabitat preferences. The nature of the interactions between species changes as the fish grow older. The distribution of habitat elements within a stream reach plays a key role in determining fish community composition. Some species and age classes prefer slow deep habitats called pools, while others use fast-water habitats called riffles. During summer age-0 coho prefer pools or back waters and steelhead and cutthroat prefer riffles. Steelhead and cutthroat change habitat preference from riffles to pools as they grow older. Thus, the ratio of fast-water to slow-water habitats in a stream reach will influence the overall species and age-class composition of a salmonid community.

Directed migrations to seasonally alternate rearing habitats within freshwater are common for some salmonid species. For example, juvenile coho and cutthroat trout exhibit seasonal migrations in and out of small riverine ponds and wetlands and other small terrace tributaries located along river floodplains. There is evidence that gross temporal separation does occur in
their use of this habitat as relatively more coho enter during fall and winter high flow periods, while more cutthroat trout enter during the spring. Temporal overlap in use does occur, however, as both juvenile coho and cutthroat are known to use these habitats together. While wintering in these hydrologically stable habitats, both coho and cutthroat are able to take

advantage of an abundant food supply and gain significant growth. The diet of coho in riverine ponds is composed of a wide variety of invertebrate fauna, including: isopods, chironomidae larvae and
pupae, oligochaete (worms), copepods, and caddisfly larvae.

Upon completing their freshwater life, juvenile salmonids of all anadromous forms undergo certain physiological changes, called osmoregulation, to enable them to move into saltwater, and at this time they are called smolts. Chum and pink salmon smolts enter the ocean soon after emergence from the gravel, spending essentially no time rearing in freshwater. Chinook smolts have evolved a broad range of early life history types, entering saltwater after from weeks to a year of freshwater rearing. Coho, steelhead, and sockeye freshwater rear for from one to three years in freshwater before going to sea. Bull trout and cutthroat trout freshwater rear for from one to five years, before going to sea.

Once in the ocean, salmonids may migrate thousands of kilometers to feeding grounds along the north Pacific coast of British Columbia and Alaska, or some may stay relatively close to their stream of origin. Anadromous salmonids accumulate the vast majority of their adult body mass in the ocean; while nonanadromous salmonids stay relatively small in size at adulthood. In the ocean most salmonid species are opportunistic feeders, feeding on crustaceans, fish, and squids; while others (e.g., sockeye) are mainly filter feeders, living almost solely on zooplankton. The ocean diet of subadult coho and chinook salmon is known to be composed of a wide variety of prey species, including: euphausiids, squid, herring, sandlance, rockfish, and anchovy.

Q. What are the main freshwater habitat requirements of the above mentioned salmonids?

A. All species of Pacific salmonids have basically similar freshwater habitat requirements. If any, or all, of these requirements are not maintained in a healthy state, then populations will decline over time and eventually go extinct or change in character. The requirements are:

1.) Free upstream and downstream access to and from spawning and rearing areas. This includes freedom from all natural and manmade migration barriers.

2.) Abundant cool/clean water. Salmon evolved in relatively cold water, free of toxics and other pollutants. Preferred water temperatures fall in the range of 10-14 degrees C. Bjornn and Reiser, 1991.

3.) Clean gravels and stable streamflows in which to spawn and rear. Gravels should be free of unnaturally high levels of fine particles of sand and silt, and flow conditions should be within natural low-flow/high-flow variability. The target condition is for no more than 11% of the particle size distribution to be comprised of the <0.85 mm fraction. This target condition applies broadly to streams of different sizes and gradients but as a general rule would be most applicable to streams <3% gradient and between 5 and 30 meters bank full channel width. Peterson et al. 1992.

4.) Frequent accumulations of small and large woody debris, to provide streambed stability, food base, and overhead cover. These structure factors will insure habitat complexity in the form of properly functioning rearing and holding pools, frequent spawning riffles, and abundant aquatic insects.

5.) An accessible food supply.

6.) A fully functioning riparian ecosystem that maintains the quality and quantity of freshwater habitat.

Q. What are the effects of deposited fine sediments and silts on salmon spawning success?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division.

An important reference for the biological effects of sedimentation is Meehan 1991. When an adult salmon selects a spawning site, it is also selecting the incubation environment. Successful incubation of embryos and emergence of fry, however, depend on many extragravel and intragravel chemical, physical, and hydraulic variables: dissolved oxygen, water temperature, biochemical oxygen demand of material carried in the water and deposited in the redd, substrate size (including the amount of fine sediment), channel gradient, channel configuration, water depth above the redd, surface water discharge and velocity, permeability and porosity of gravel in the redd and surrounding streambed, and velocity of water through the redd.

Fine sediments (inorganic particles smaller than 0.850 mm diameter) can become deposited in spawning gravels during and after forest practices activities. Sediment sources are from road construction, timber harvest, and yarding activities. Mass soil movements (landslides) following road construction and timber harvest can also produce large quantities of fine sediments in salmon streams. Cederholm and Salo 1979; Reid 1981. The amount of fine sediment washing from the unpaved surfaces of logging roads under varying use levels, and from other forms of soil disturbance, can also cause significant amounts of fine sedimentation to streams. Reid and Dunne 1984. Fine sediment that settles in streams or moves in suspension can reduce salmonid viability.

Determination of the effects that deposited fine sediments have on salmonids is complicated by the variability in responses among salmonid species and by the adaptability of salmonids to ambient sediment levels. Fine sediment deposited in spawning gravel can reduce interstitial water flow, leading to depressed dissolved oxygen concentrations, and can physically trap emerging fry in the gravel.

During incubation, sufficient water must circulate with oxygen and carry away waste products. Circulation of water through redds is a function of the porosity (ratio of pore space to total volume of redd) of the particles in the redd, hydraulic gradient at the redd, and temperature of the water. Porosity is highest in newly constructed redds and declines during the incubation period as the interstitial spaces acquire fine sediments. The definition of what is a “fine” sediment varies depending on the species of salmon that is being studied, and the region where the study is being conducted. The hydraulic gradient through a redd is enhanced by the mounded tailspill created during construction. Permeability (ability of particles in the redd to transmit water per unit of time) and apparent velocity (volume of water passing through a given area of redd per unit of time) are two commonly used measures of the suitability of a redd for successful incubation of salmonid embryos. When the permeability and apparent velocity of water in the redd have been too low, reduced embryo survival has been measured for sockeye salmon, steelhead trout, chinook salmon, pink salmon, and coho salmon. Therefore, salmonid embryo survival decreases as apparent velocitites (an indication of the amount of dissolved oxygen reaching the embryos) decreases. Meehan 1991.

Once incubation is complete and the salmon fry are ready to emerge from the redd and begin life in the stream, they must move from the egg pocket up through interstitial spaces to the surface of the streambed. It has been concluded that emergence of salmonid fry was a response primarily to gravitational cues rather than to light or intragravel water flow. Emergence can be a problem if the interstitial spaces are not large enough to permit passage of the fry. This can result in entombment of the fry within the gravel. Peterson et al. 1992.

Fine sediments that impede intragravel flow and fry movements may also affect the size of emergent fry and the time of emergence, but such effects were not seen in all studies. Tagart 1976.

The target condition is for no more than 11% of the particle size distribution to be comprised of the <0.85 mm fraction. This target condition applies broadly to streams of different sizes and gradients but as a general rule would be most applicable to streams <3% gradient and between 5 and 30 meters bank full channel width. Peterson et al. 1992.

Q. What are the effects of suspended fine sediments and silts on juvenile salmonids swimming within the water column?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division.

This information is generally borrowed from Noggle(1978). The direct effects of suspended sediments on salmonids are probably less than the impacts of deposited sediments, mainly because they occur in quite low concentrations and duration, and the fish can avoid it. Studies of the effects of suspended sediment on trout in natural streams have produced a wide range of results. Caged rainbow trout (O. mykiss) were killed within 20 days in the Powder River, Oregon, when the suspended sediment concentration was 1,000 to 2,500 ppm. Streams carrying high concentrations (5,100 ppm) of suspended china-clay sediment had as low as oneseventh the density of brown trout found in control streams. Reduced trout abundance was also observed in concentrations of 1,000 ppm, but no adverse effects were seen at 60 ppm. Concentrations of kaolin clay or diatomaceous earth suspensions reduced rainbow trout survival over four to five months of exposure. Others found reduced growth for rainbow trout exposed for nine months in 220 ppm coal washery solids, and 96-hr LC50 (the concentration causing 50 percent mortality in 96 hours) of 28 and 55 g/l for chum salmon fry exposed to two natural suspended sediment sources. Sublethal effects have also been observed through histological studies. This work revealed epithelial swelling and fusion of adjacent gill lamellae.

Other work indicates seasonal changes in the tolerance of salmonids (juvenile coho and steelhead) to suspended sediment. Bioassays conducted in summer produced LC50's less than 1,500 mg/l, while autumn bioassays showed LC50's in excess of 30,000 mg/l. Histological examination of gills revealed structural damage by suspended sediment. Blood chemistry showed elevated blood glucose levels at sublethal suspended sediment concentrations.

Q. What would be the impacts of sedimentation on salmonid habitat and salmon, in the rivers and creeks that this pipeline will cross?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division.

Direct sediment runoff could occur at pipeline construction right-of-ways, contractor construction yards, pipeline ditching sites (dry and wet), and possible landslides caused from undermining of slopes. Sedimentation from these operations could cause important short-term negative impacts to adult and juvenile salmonids holding and rearing in the streams, and on eggs and fry that may be incubating in downstream spawning gravels. According to the contractor application report (2.3 Construction on Site) certain erosion control measures will be taken by the contractor. Methods will be site-specific, depending on the soil conditions, slope, and other site-specific variables, but may include silt fences, straw bales, rock bases, sedimentation ponds, and dust control. Three main methods will be used for water crossings, including open-cut channels, directional drilling, and bridge crossings, the first two types of crossings have potential to cause stream sedimentation. Sediment generated at the construction right-of-way clearings and at the stream crossings, could run off site and cause sedimentation to salmon streams or tributaries thereto.

Sediment runoff is especially a problem during unexpected rain storm events. During the initial year of construction, erosion and runoff into salmonid bearing streams is very likely. The resulting sedimentation may intrude into spawning gravels immediately downstream of the construction site, and in off-site spawning habitats that may be located considerable distances downstream. This material could cause stress and even mortality to adult and juvenile fish, as well as incubating eggs. The duration of impact will probably be short-term, at least until the next stream-bed scouring storm event. In this climatic area, stream-bed scouring events occur on an annual or semi-annual basis. There are a number of river and stream crossing sites that could potentially impact salmonids and their habitats.

Q. What would be the impacts of turbidity, loss of shade, lowered LWD loadings, and water temperature increase, on salmonid habitat and salmon, in the rivers and creeks that this pipeline will cross?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division.

Impacts of Turbidity - Turbidity is determined by the ability of water to transmit light, and expressed in either JTUs or NTUs, Jackson Turbidity Units or Napthalene Turbidity Units, respectively. When the amount of suspended sediment in the water is high, JTU and NTU readings are also high. Sometimes JTUs are expressed in parts per million (ppm), by assuming equivalence to a concentration of a standard silicone dioxide or formazin suspension. This has generated confusion in the literature because many authors also refer to gravimetrically analyzed samples in ppm. Gravimetric analysis involves filtering, drying and weighing a sample by accepted techniques. A gravimetrically analyzed sample should be reported as a weight-to-volume measurement such as milligrams per liter (mg/l) or grams per liter (g/l), while parts per million refers to a weight-to-weight measure. Measurements of JTUs and mg/l for a particular stream are sometimes reasonably well correlated with each other.

The correlation between JTUs and mg/l becomes clouded when comparing between different streams and sediment sources. For example, glacial sediments characteristically have a different specific gravity than sand or soil sediments. It appears that the best method of measuring suspended sediment concentrations is generally a standard gravimentric analysis. The results should be expressed in weight per volume units (mg/l or g/l), not parts per million (ppm). The direct stressful or lethal effects on fish are correlated with the quantity of a particular sediment source which is most accurately measured gravimetrically.

Suspended sediment levels that may result from pipeline construction activities could have both lethal and sublethal effects on fishes living downstream of the construction site. As was discussed in an earlier section (Noggle 1978), tolerence of juvenile salmonids exposed to suspended sediments may vary significantly by season of the year. Sediment can clog and abrade gill membranes, causing fish to suffocate or change behavior. In Noggles work, the lowest tolerance to suspended sediments (turbidity) was found to occur in the summer months, the time of year when pipeline construction will be happening. It is doubtful that the levels of suspended sediments will reach levels conditions, however, it is very likely they could reach levels that cause sublethal stress or redistribution that could lead to death. When under stress salmonids become more vulnerable to disease, or change their normal behaviorisms and distributions, potentially causing both increased competition and possibly direct mortality.

Turbid conditions can also lower light transmittance in the water column, thus lowering photosynthesis and aquatic insect production. Aquatic insects make up roughly half the diet of juvenile salmon and other fishes. Under the worst conditions this could lead to starvation, indirectly lead to death at a later stage in life. Therefore, turbid conditions should be minimized.

Loss of Shade - The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division. Shade is important because it shields the streams and fishes from direct sunlight and moderates increases in water temperature. Salmonid fishes prefer to live in water temperatures in the range of 12-14 degrees C (Meehan 1991). Water temperature actually regulates the bodily functions of salmonids due to there being cold blooded, and also determines the level of oxygenation of the water. The saturation level of oxygen in water is inversely correlated with water temperature. Changes in stream temperature can have both direct and indirect consequences for salmonid production. An example of a direct effect would be adult and juvenile salmonid death due to direct exposed to extremely high water temperatures and suffocation (i.e., 20 degrees C. plus range). An example of an indirect cause of fish mortality could be due to increased metabolism rates pushed beyond the normal range. If sufficient food is unavailable, then juvenile salmonids could actually over graze there habitat, and eventually starve to death. Subtle, low level increases in water temperature can be beneficial to growth, if sufficient food is available. Adult salmon can die due to suffocation from low oxygen levels in the summer. Streamside clearing for pipeline construction could cause loss of shade and consequent increases in water temperature. This could result in both direct and indirect impacts on fish living in downstream areas. These impacts can also be cumulative when they combine with other causes of temperature increase in the watershed (i.e., logging, suburbanization, etc.).

Lowered LWD Loadings -

The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division. Among the most important long-term effects of forest management on fish habitat in western North America have been changes in the distribution and abundance of large woody debris (LWD) in streams. According to Peterson et al. (1992) the amount of LWD in streams and rivers has been related to salmonid abundance and distribution. Most LWD originates in the riparian corridor along rivers and streams, entering the aquatic system by such processes as gradual streambank undercutting and channel migration, and more catastrophic inputs such as windthrow, and mass wasting. The main LWD recruitment area being within a distance of 100-200 feet either side of stream courses.

Large woody debris provides many functions as salmonid habitat, including: providing a form of overhead cover and deep pool area, spawning gravel retention, temperature control, streambed and streambank stability, and as a source of organic substrate for aquatic and terrestrial insects. Some research has indicated that LWD frequency decreases with increasing channel width, with the greatest accumulations in smaller channels and less in large channels.

This was probably highly variable under natural conditions, when one considers the records of fairly large accumulations in some of the larger rivers of the Pacific Northwest (Meehan 1991; Peterson et al. 1992). Today, LWD accumulations are greatest in forested areas upstream of urban development. This is particularly true in streams that have been cleared of debris along highways and around urbanized communities. There has also been extensive debris clearing in forested streams, under the false claim that it would improve salmon migration. The abundance of salmonids is often closely linked to the abundance of LWD, particularly during winter. Large woody debris creates a diversity of hydraulic gradients that increases microhabitat complexity, which in turn supports the coexistence of multispecies salmonid communities (Meehan 1991).

If forest clearing occurs within the 100-200 foot zone along the rivers and streams during pipeline construction, then an important source of LWD may be lost. How significant this is to salmonid habitat will depend on the amount of clearing and it's proximity to the water course. The impact to salmonid habitat along smaller streams and wetland would probably be more significant than along large rivers, just due to the area of influence. Small streams and wetlands have less LWD source area, while large rivers are re-supplied with debris from various upstream watershed areas. This impact is one that will potentially have both short and long-term implications for salmonids.

Q. What are the effects of streambed dewatering on salmonid eggs?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division. Salmonid embryos can survive shortterm redd dewatering when the dewatering occurs before hatching. If water temperatures remain within a suitable range, fine sediment concentrations do not impede intragravel circulation, and humidity is maintained near 100% within the redd (Meehan 1991). In a moist environment, unhatched embryos are able to get the oxygen they need from the dissolved air within the redds. In many cases survival remains relatively high as long as the humidity is >90%.

Q. What are the effects of decreased streambed stability on salmonids?

A. The information in this section may have applicability to other testimony by Dr. Susan Shaw, Todd Bohle, and Nancy Sturhan, of the DNR Forest Practices Division. Salmonids use the substrate for both an incubation environment for eggs, and an overwintering habitat for juveniles (Meehan 1991). Eggs are buried in the gravel substrate during spawning, where they are supposedly protected from streambed scour during flooding. Juvenile salmonids that spent a year or more in freshwater rearing, often bury themselves within the substrate crevices during winter, to avoid being washed downstream. These behaviors have evolved since salmonids first occupied the rivers and streams of the Pacific Northwest. They have proven to work for the salmon, under longterm climatic cycles. However, when man directly or indirectly destabilizes streambeds, they can become less stable than would occur under natural conditions, this can cause both eggs and juveniles to be displaced and killed during normal high flow events. River crossings during pipeline construction, that result in streambed destabilization, could result in loss of both eggs and wintering juvenile salmonids.

Q. What are the effects of river channel migration on the stability of the pipeline?

A. Rivers have a predictable sequence of recurring deep pools and shallow riffles (Leopold et al. 1964), as part of the natural meander pattern. Riffles are locations of relatively shallow depths and pools are relatively deep locations. Streambeds can be scoured to considerable depth during floods, depending on the magnitude of the flood and the location within the streambed profile. After the flood subsides, deposition occurs. Judging the amount of scour that may occur at a given location is difficult, it is generally dependent on watershed area upstream, amount of runoff, and occurrence of debris. When the river discharge increases during a flood, there is an increase in flow velocity and streambed shear stress (erosion potential). As a result, the channel bed tends to scour to depths that could expose a buried pipeline. Because sediment is being contributed from upstream, as the shear decreases with the fall of the flow the sediment tends to redeposit. If a river should catastrophically move across its floodplain, and establishes a new channel, a new sequence of pools and riffles will be established. Pool depths of three or more meters are not uncommon, depending on the size of the upstream watershed. If a new pool should form where a pipeline has been buried, the pipeline could be exposed and ruptured during a flood event. If salmonids are in the downstream vicinity of such an occurrence, eggs and/or juveniles could be scoured away.

All of the above noted potential impacts could potentially occur at seventeen "invasive stream crossing sites with salmonid spawning habitat present at or just downstream of the site." (See the DEIS Table 3.7-2).

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I certify and declare under penalty of perjury under the laws of the State of Washington that the foregoing is true and correct to the best of my knowledge and belief.

SIGNED AT ____________________, Washington on this _________ day of February, 1999.

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Carl Jeffrey Cederholm